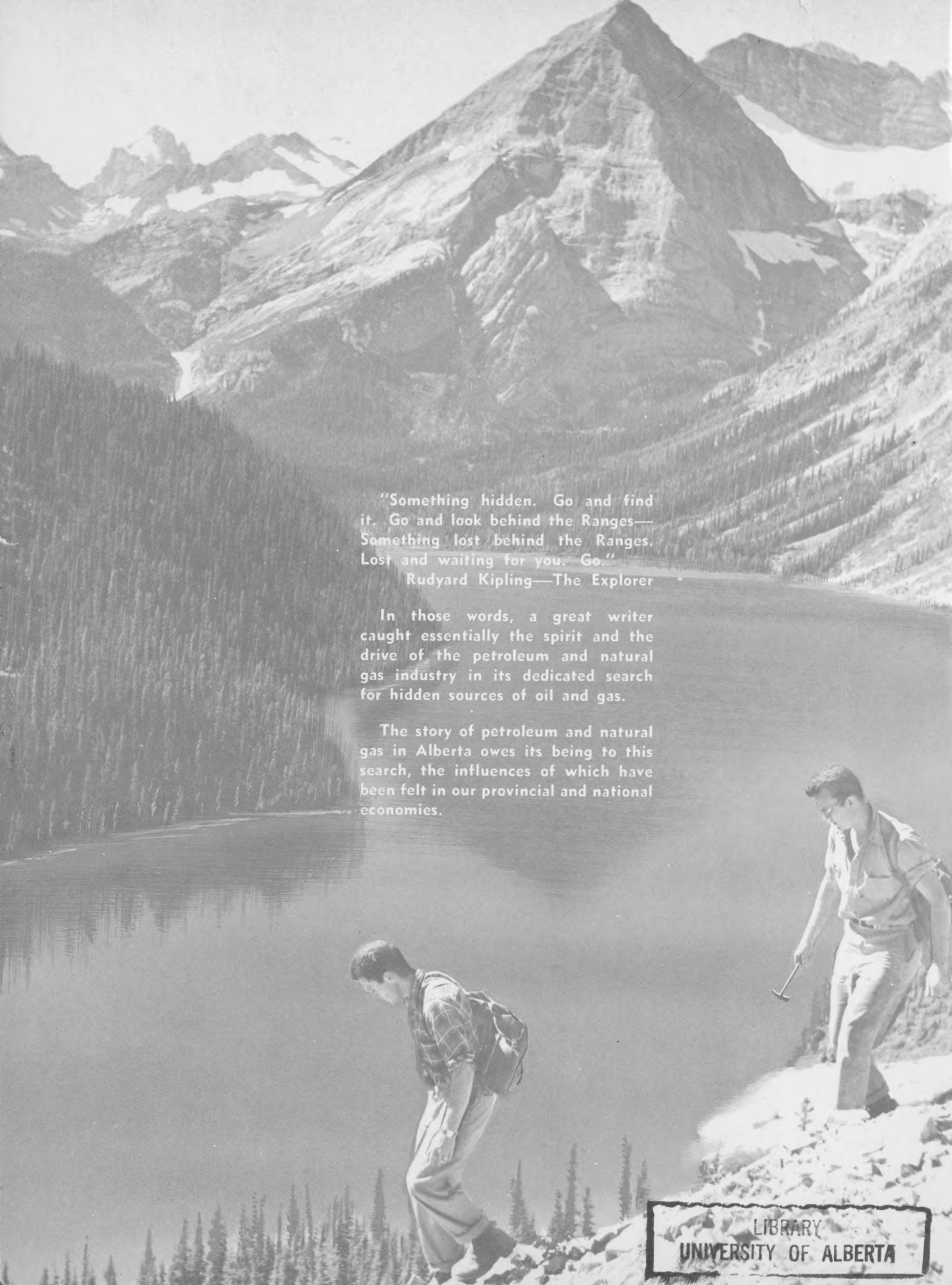
OIL AND GAS IN ALBERTA

CANADIAN PETROLEUM ASSOCIATION



"Something hidden. Go and find it. Go and look behind the Ranges—Something lost behind the Ranges. Lost and waiting for you. Go."

Rudyard Kipling—The Explorer

In those words, a great writer caught essentially the spirit and the drive of the petroleum and natural gas industry in its dedicated search for hidden sources of oil and gas.

The story of petroleum and natural gas in Alberta owes its being to this search, the influences of which have been felt in our provincial and national economies.

PREFACE

This booklet has been prepared by the Alberta Division of the Canadian Petroleum Association for free distribution to Alberta schools.

In addition to explaining some of the technical aspects of exploration, production, transportation and manufacturing, it outlines the development of the petroleum and natural gas industry in Alberta, and examines the industry's contribution to the province and the nation. For this reason it is hoped that the booklet will have particular significance to the Alberta student.

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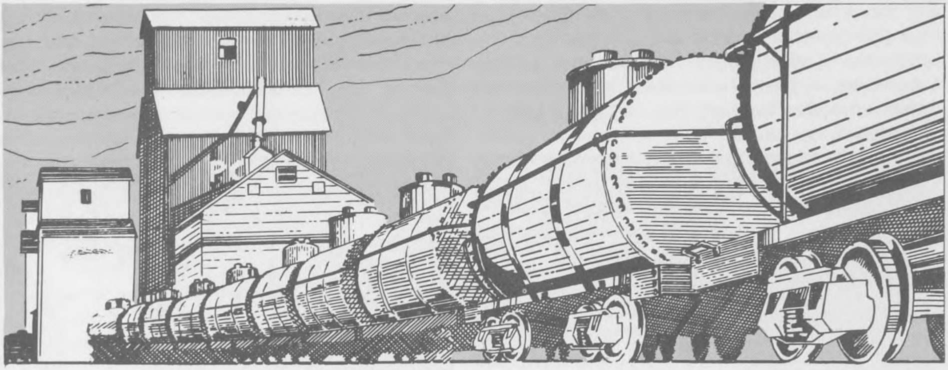


CHAPTER I

IN THE BEGINNING

It was once said of Alberta that no traveller was ever out of sight of a grain elevator for very long.

These prairie sentinels identified the kind of country through which one travelled — the more elevators there were the better the land for farming. In recent years new landmarks have been springing up. As the last rays of the sun slant off the elevator roofs, new lights are seen in the gathering darkness. They are the lights that mark the tall derricks where men are working to find a new crop far below the fields of grain. Here and there a sparkling complex of tanks, tubes and pipes identify gas plants and oil refineries glittering in the night like a fantasyland spectacle.

This is the new Alberta, and this is the story of how it all happened. It is a story of human ingenuity, reaching back far beyond recorded history to the very dawn of time upon this planet, for materials with which to mold a better society today. Those tall masts of drilling rigs are in fact symbols of our industrial revolution. Man is taking material that has been locked in the earth for hundreds of millions of years and converting it into heat for our homes, fuels for our cars, clothing, lubricants and an almost infinite variety of synthetic materials from plastic bags to water pipes.

All of this comes out of the ground, and yet much of what is taken, of what is going on, is never seen. A network of pipe lines covers Alberta just below the surface. Gas and oil are gathered from wells and transported to processing plants and refineries. Other pipe lines take the oil to markets in the Pacific Coast and as far away as Ontario and the State of New York. Still other lines move Alberta natural gas out of the province to California and eastward to Montreal and the central United States.

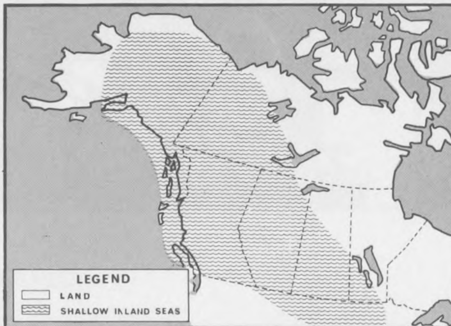
Of this, we see only the cautionary signs which warn us when high pressure pipe lines cross under roads and fields. Alberta came to maturity as an oil and gas province at an opportune time. While the drilling industry was proving up the vast reserves of oil and natural gas under Alberta, the steel industry was improving the manufacture of big-inch pipe lines. The size of the pipe doubled and redoubled until today our natural gas moves in pipe a yard in diameter. The development of these large diameter pipes has made it economically possible to move oil and gas over great distances at low cost. Today the natural resources of Alberta sell in distant markets which could not have been reached otherwise.

There is constant exploration in Alberta for oil and gas and this is an important part of a ceaseless global pursuit. Fortunately, Alberta has been endowed with some of the world's most attractive hunting grounds in an area of 200,000 square miles.

Except in rare cases, oil and gas are found only in sedimentary rock (rock formed by sediments deposited in ancient inland seas millions of years ago). Almost all of Alberta is prospective oil and gas area because most of the province lies within the Western Canada Sedimentary Basin.

Petroleum, which actually means "rock oil", was so named because it is found in certain types of rock. These, known as sedimentary rocks, serve as store houses deep underground for both petroleum and natural gas. Petroleum and natural gas are frequently found together in the same reservoir. Sometimes we find just oil with almost no gas; sometimes just natural gas.

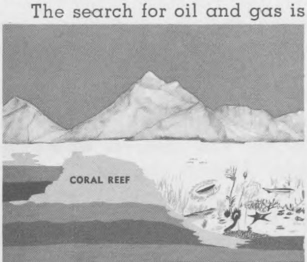
The search for oil and gas is one of nature's greatest challenges. It was hundreds of millions of years ago when the story of oil and gas started with the marine life of ancient seas that covered most of the continents. During these millions of years the waters lapped across Alberta along with much of North America. The



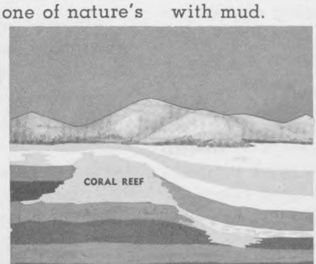
In the Upper Devonian period several hundred million years ago western Canada, along with much of North America was covered by shallow inland seas. Seventy per cent of Alberta's present oil reserves have been found in reefs which grow in these seas and which are now buried under thousands of feet of sediments.

subsurface of Alberta consists almost entirely of the elevated floors of ancient seas.

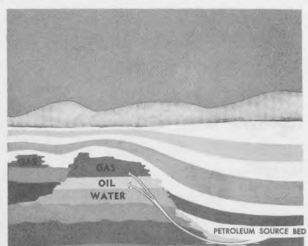
The seas contained future petroleum in the form of untold billions of tiny plants and sea creatures. These fish, crustaceans, diatoms and their assorted one-celled marine companions lived out their span in those warm seas; then sank to the bottom where they were blanketed with mud.



The simple forms of marine life in ancient seas were the source material for petroleum.



Through the ages sediments drape over the coral reef and cover the organic remains.



Petroleum source b e d s were formed by pressure of the compacting sediments and other forces. Gas and oil then migrated into the porous reef traps.

As ages passed, these organisms changed to petroleum and the seas withdrew. In the process, over millions of years, remains of the marine life continued to be covered by sediments, layer by layer. There were layers of sand; layers made up mostly of shells of small sea things; and still more layers of mud.

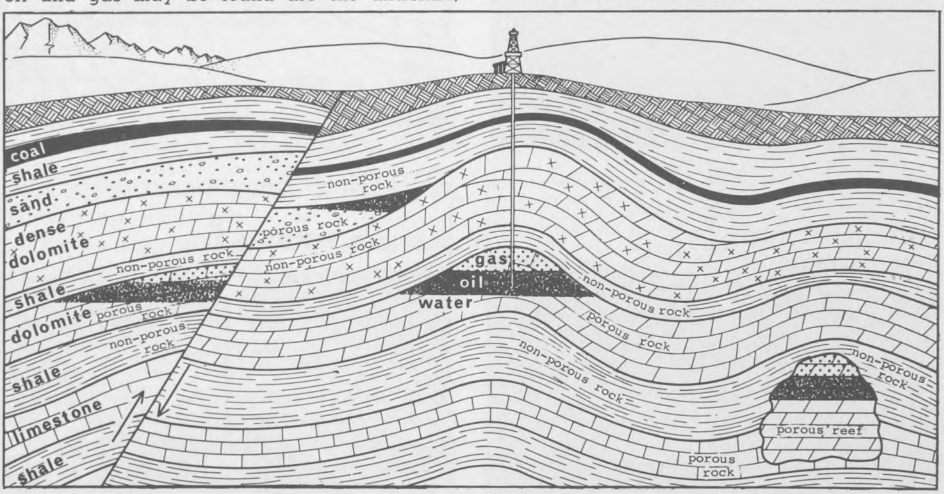
The sediments turned into rock as more millions of years went by. Mud became shale; sand became sandstone; shells became limestone. Opinions vary on just how the buried remains of marine life changed into petroleum, but bacterial action, heat and pressure are believed mainly responsible.

Along with the organic matter, water, usually salt water, often was trapped in the sediments. Because oil is less dense than water, and gas less dense than oil, if trapped in a suitable underground structure they position themselves accordingly, with gas at the highest point in the trap, oil next, then water below. They may be found, however, alone or in any combination.

In western Canada, the four most important types of geological structures, or traps, where oil and gas may be found are the anticline, the fault trap, the stratigraphic trap and the reef. These are but a few of the known geological structures, but all types of structures have an essential, common aspect: a porous rock to serve as an oil and gas reservoir and an overlying non-porous rock to prevent the escape of oil and gas. Without such traps there could be no accumulation of oil and gas; for they would escape to the surface — leaving behind only an asphaltic deposit.

In searching for these traps, oilmen drill holes many thousands of feet into the ground. Well depths in Alberta range from around 2,000 to 15,000 feet. Wells about a mile deep are commonplace.

To serve as a good reservoir, the rock in the trap must be more than just porous. It must have sufficient pores or spaces to hold enough oil or gas to justify the expense of bringing the well into production; and the pores must be connected to permit the oil and gas to move through the rock. The extent to which there are pores or spaces is a measure of porosity; the extent to which the pores are connected is a measure of permeability.



FAULT TRAP — the strata have slipped so that a porous layer of rock is shoved against a non-porous layer.

STRATIGRAPHIC TRAP — caused by a "pinching out" of a porous rock layer between non-porous rock layers.

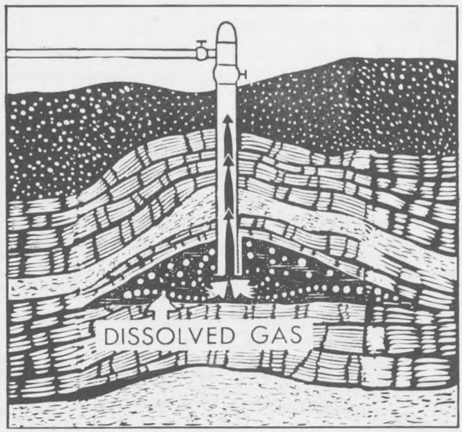
ANTICLINE — an upward arching of the rock strata. Oil and gas can collect in the porous rock, beneath the "inverted bowl" of non-porous rock.

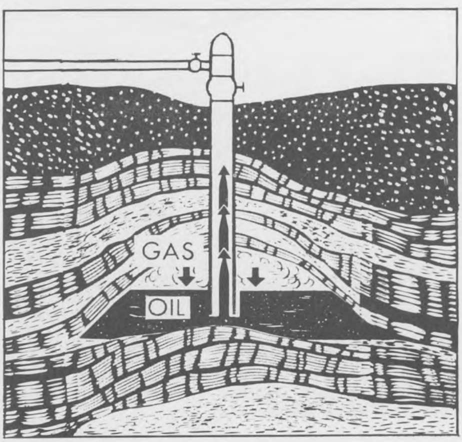
REEF — a porous mound or mass built by animals such as corals.

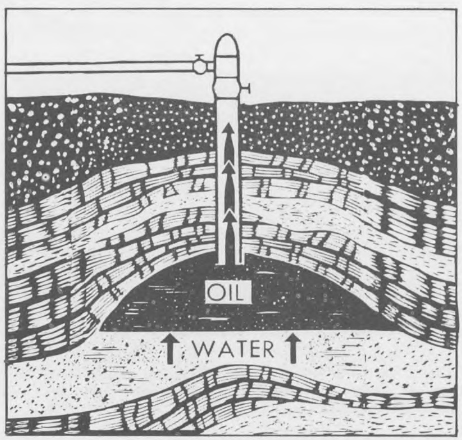
Finally, the oil must be under pressure in the reservoir. Otherwise it would not move out of the reservoir to the drill hole. The oil is moved by upward force of water below it, by gas compressed into the oil itself — called dissolved gas or solution gas — or in certain cases by free gas, under pressure, lying above the oil in the form of a gas cap. These pressures are the result of the weight of overlying rock. Some fields have a combination of these energy drives, but in any given field usually one type will predominate.

Sooner or later as the wells are produced, the natural pressures exerted by gas or water, or both, will decline. When this happens either pumps must be installed in the bottom of the wells to lift the oil to the surface, or reservoir pressure must be supplemented. In the latter case, water or gas is pumped down injection wells to the producing formation. This is called pressure maintenance, or secondary recovery, and it creates a flushing action which increases the recovery of oil. The pressure maintenance program in Alberta's Pembina oil field is the largest of its kind in the world.

Types of energy drives appearing in oil fields. In dissolved gas drive, expanding gas moves the oil; in gas cap drive, expanding gas displaces the oil downward; in compressed water drive, the water below forces the oil upward.







CHAPTER II

BEFORE LEDUC

Recent oil and gas history in Alberta begins with the famous Leduc discovery in 1947. The expressions "before Leduc" and "after Leduc" have become commonplace and self-explanatory summations of Alberta's progress since that year.

The '47 oil discovery near Leduc, thirty miles southwest of Edmonton, attracted widespread attention to Alberta, and it became a focal point in the international oil search. The exciting promise of that time has been fulfilled. The names of Alberta oil and gas fields, such as Redwater, Pembina, Swan Hills, Pincher Creek, Cessford, Homeglen-Rimbey, Westerose South and Golden Spike have emerged as part of the language of the oil world. Vast reserves of natural gas were discovered at the same time.

Although developments in Alberta dating from 1947 overshadow all preceding events in the Canadian petroleum industry, there are other and older milestones.

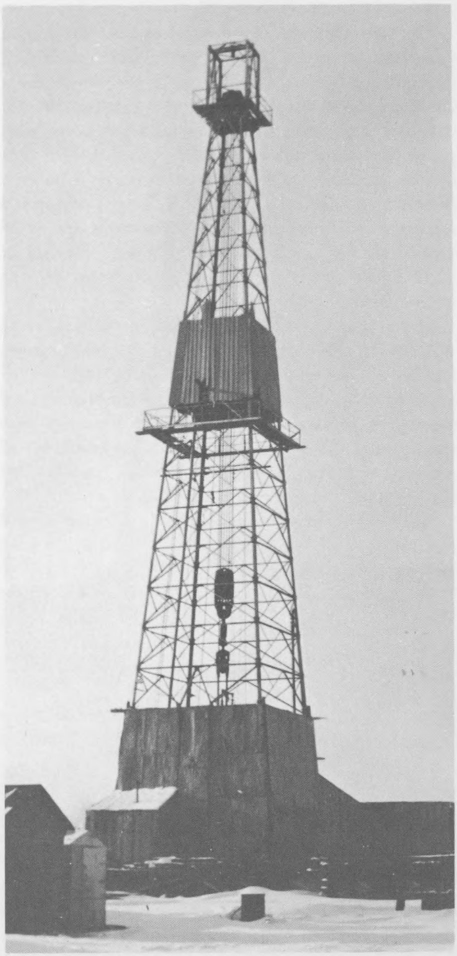
Petroleum has been used in one form or another as far back as civilization can be traced. There is evidence in ancient records that it was used first in the form of asphalt; for unlike fluid petroleum, the mysterious gummy substance would not evaporate and disappear. As far back as 6,000 B.C., it was used to water-proof boats and hold bricks together, and for heating, lighting and lubrication.

Among many references to petroleum in the Bible are those which suggest its use in building roads and lighting altar fires. Also, Noah's Ark was coated "within and without with pitch"* and Job recalled a peaceful time when "the rock poured me out rivers of oil."*

About 3,000 B.C. the Egyptians started building the pyramids and the sphinx. Asphalt, one of the materials used, was imported from the Near East countries. The Dead Sea rendered a great deal of the ancient asphalt. (It has been told that Mark Antony once gave Cleopatra all the asphalt of the Dead Sea area, but out of some unknown feminine whimsy she was less than impressed with the gift.)

*Gen. 6:15; Job 29:6.

History and legend report that the Greek, Roman and Persian civilizations enjoyed the advantages of petroleum. Some of the uses,



The Leduc No. 1 discovery well introduced a new era for Canada's petroleum industry.

however, involved quite weird military applications. This sounds like the most ignoble of victories, but it is said that a Roman general won a battle against the Vandals by coating pigs with oil and driving them as blazing torches against the enemy. It is part of legend that a 7th Century Shah of Persia claimed victory over an elephant-supported Indian army in much the same way. But he used inanimate objects (hollow iron horses mounted on wheels) filled with burning oil.

In the New World, Indians of the North American continent knew petroleum as an old friend long before the arrival of the white men. Once on the scene, white men naturally did not care for the Indian use of petroleum as war paint, but they did adopt the Indian belief that it was a fine medication for various ailments. Indians of Alberta's great Athabasca oil sands region used "tar" from the oil-soaked sands to gum their canoes. This activity was viewed in 1788 by Peter Pond, the first white man ever to travel in that area.

By virtue of these oil sands, Alberta has within its borders the world's largest known single oil reserve. This has attracted worldwide interest, but for many years no economical means of freeing the oil from its sandy prison could be found. The first permit for commercial development of the oil sands was granted by the Alberta Government in 1962.

New petroleum uses were developed about the middle of the 1800's, and it could be said that the way was lighted by the need for better illumination and greased by the need for better lubricants. Supplies for these purposes came from oil springs and patches of asphalt.

Illuminating oil for lamps was named "kerosene" by Dr. Abraham Gesner of Nova Scotia, whose research and development work laid the foundation for production of petroleum products by the early petroleum refiners.

A rapidly growing need for such products made it necessary to "dig" for oil. Such digging or drilling was far from new in history, for the ingenious Chinese had drilled in search of oil and gas several centuries before the Christian era. Over two thousand years were to pass, however, before systematic drilling for oil marked the beginning of the present petroleum era.

The pioneer work of James Miller Williams in 1857 made Canada the birthplace of North America's petroleum industry. In Lambton County, Ontario, in the vicinity of the present site of Oil Springs, about 44 miles south of Sarnia, Williams dug for oil, found it, refined it, and sold it as lamp oil.

Two years later Col. Edwin L. Drake earned another proud place in oil industry history. In 1859 Col. Drake drilled the first oil well in the United States, and this venture at Titusville, Pa., touched off a great expansion of the industry started by Williams.

There were some in the United States who feared the petroleum era and wanted drilling to stop. According to one petitioner the fires of Hades would go out with removal of the fuel supply. Another cautioned President Abraham Lincoln that petroleum was meant for greasing the axletree of the earth as it revolved.

Canada's first natural gas discovery occurred in Alberta's Suffield area in 1883. This discovery was considered a nuisance, because they were searching for water needed for wood-burning locomotives of the Canadian Pacific Railway.

In 1890 another search, this for coal, turned up Medicine Hat's first gas discovery. This led to later field development when the importance of gas was recognized.

In 1891 drilling took place in the Pincher Creek area where oil seepages had been found and used for lubricating machinery as early as 1866.

In 1902 a well drilled near a seepage in the vicinity of Waterton National Park rewarded drillers with oil production. It was the first oil well but it produced only for a short time. Even so, it lent encouragement for more exploration and the southwestern foothills region became the cradle of Alberta's oil industry.

In 1904 a well drilled by the town of Medicine Hat was completed as a gas producer and launched the first commercial development of a field in Alberta. This development resulted from the 1890 discovery.

In 1909 a gas well fondly remembered as "Old Glory" resulted in development of the Bow Island gas field as the original source of gas for Calgary and Lethbridge. Alberta was just four years old and "Old Glory" was Canada's greatest producer to that date. Its discoverer, Eugene Coste, has been called the father of the natural gas industry in Canada. The honour traces back to 1889 when he brought in Ontario's first commercial discoveries of natural gas.

Discovery of natural gas at Viking in 1914 also resulted in field development. For many years this field was the only source of supply for Edmonton and other points in central Alberta.

The Calgary Petroleum Products No. 1 well in Turner Valley in 1914 became the most spectacular Alberta oil discovery. It was known as the Dingman Well and was drilled by a group of pioneer oilmen headed by William Herron. The company eventually was taken over by Royalite Oil Company which drilled the famous Royalite No. 4 in 1924, the greatest gas well known in Canada to that time. The gas was rich in naphtha (natural gasoline) and from 1924 to the mid-thirties many wells were drilled into the Turner Valley gas cap for recovery of naphtha.

In 1925 the Wainwright field was discovered. It was the first crude oil discovery of commercial significance on the Alberta plains.

In 1936 Turner Valley hit its stride as an outstanding crude oil field. It entered this stage of growth when Turner Valley Royalties No. 1 came into production in the Rundle limestone of Mississippian age.

This led to increased drilling, and for many years Turner Valley provided most of the oil used in Alberta. This production was just a mere fraction of the oil being imported to meet the nation's needs for products.

In short, Canada was an oil deficient nation. Williams' discovery in Ontario in 1857 had been followed by development of only one major oil field other than Turner Valley. This was the Norman Wells field, discovered in 1920, near the Arctic Circle.

Between the Turner Valley and Leduc discoveries, the gas strike at Jumping Pound outside Calgary was the only important discovery.

Leduc Day was February 13, 1947.

The company responsible for the Leduc discovery had drilled 133 dry holes costing more than $23 million in a 30-year search to find more oil.

When Imperial Leduc No. 1 "came in," it was called appropriately "the advance agent of a new era for Canadian oil." The Leduc discovery actually provided three oil fields and one gas field. The two main oil producing zones in each case are coral reef formations (limestone) believed to have been formed about 275 million years ago when seas covered the Western plains.

The Calgary Petroleum Products No. 1 well, later known as the Dingman well, discovered the Turner Valley field in 1914.

CHAPTER III

LAND - The Foundation of the Industry

Land is the foundation of the oil industry. Before the drilling rig begins its downward probe, the right to search for and take oil and natural gas must be acquired, as well as the right to use the surface of the land. Obtaining these rights is one of the first steps in the search for petroleum.

In western Canada, where most of the nation's oil and gas lands are located, there is a mineral ownership situation which is somewhat unique. It has its roots in early Canadian history.

In Alberta, for example, the Provincial Government holds about 81 per cent of the mineral rights; about 9 per cent are held by the Federal Government in National Parks and Indian Reserves; and 9.5 per cent are owned by other interests including the Canadian Pacific Railway and the Hudson's Bay Company. Less than 1 per cent of the mineral rights are owned by "free holders" — the individuals who own mineral rights. By contrast, in the United States most of the mineral rights are privately owned, usually by the same persons who own the surface rights.

The Canadian situation results from the legal principle that all land was originally owned by the Crown and became privately owned by a grant from the Crown. In the year 1670 the Hudson's Bay Company obtained from King Charles II of England an immense land grant of approximately 1.5 million square miles — the land drained by streams flowing into the Hudson's Bay. The grant included all surface and mineral rights. Although most of the land was returned to the Dominion Government shortly after Confederation, the Hudson's Bay Company still holds substantial surface and mineral rights in western Canada.

The Canadian Pacific Railway, completed in 1885, had received a grant of 23 million acres of land to provide assets to help the Company finance the project. The land grant was situated in Manitoba, Saskatchewan and Alberta, and included surface and mineral rights. Although the majority of the surface rights in Alberta have been disposed of, the C.P.R. still controls the mineral rights underlying about 8.25 million acres in Alberta.

In addition to the C.P.R., several lesser syndicates were formed for the building of spur lines, and these companies received similar grants of land.

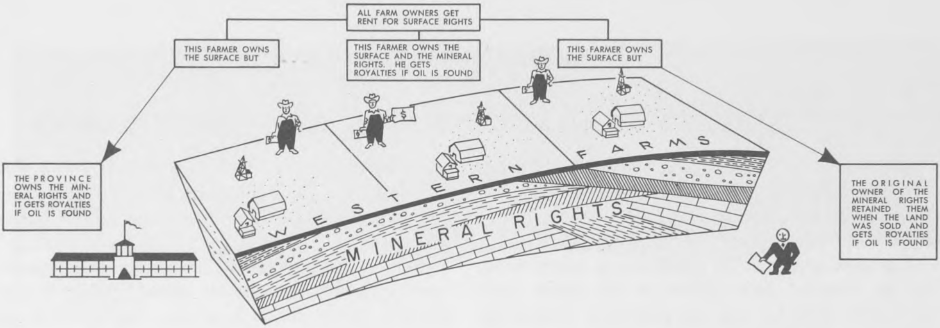
As mentioned previously a small percentage of the oil prospective land in Alberta is held by individual freeholders. The difference in the extent of freehold land among the western provinces is related to the gradual settling of western Canada and the date after which mineral rights were no longer granted by the Crown to the homesteader.

As the pioneers made their way into the prairie provinces, they were granted homestead rights (mineral and surface) by the Crown. After 1887 only surface rights were granted. Because British Columbia and Manitoba were settled and incorporated before Alberta and Saskatchewan, the former provinces contain a greater percentage of freehold. Under the British North America Act of 1867, ownership of Crown lands, royalties, mines and minerals was retained by those provinces entering Confederation. When British Columbia became a province in 1871, that province retained its mines and mineral rights. The remaining western provinces did not receive a transfer of mineral rights until 1930.

Because of the competition among members of the industry for rights to acreage, acquisition of exploration rights and petroleum and natural gas leases is one of the most exciting phases of the industry. The Provincial Government holds the majority of the mineral rights in Alberta; therefore most rights are obtained by submission of sealed bids to the government. Rights owned by freeholders and land holding companies are acquired by negotiation with the owner.

Rights granted oil and gas companies may be held in a variety of forms. Each covers a particular phase of operations. For example, there are leases (petroleum leases, natural gas leases, and petroleum and natural gas leases), reservations, permits and licences.

There are many set requirements which must be fulfilled after such rights have been acquired. There are regulations designed, for instance, to



encourage the oil company to step up its exploratory drilling so that more oil and gas may be found. These regulations have been developed over a period of several decades, and continue to be subject to gradual change. In this way they reflect the province's interest, as a mineral rights owner, in encouraging exploration and providing for maximum utilization of this natural resource.

Discoveries are important not just to the operator who made the discovery, but also to the owner of the minerals. The latter receives, on the average, one-eighth of production in the form of royalty payments.

Most landowners have title to surface only, and do not hold mineral rights. But surface rights owners are compensated for the use of the land. There are initial payments on a per acre basis for each surface lease and additional payments for wellsites, access roadways, tank batteries, pipe line easements, power lines, etc. Compensation then is followed by payment of annual rentals throughout the lifetime of the well.

Amounts to be paid for the use of the surface are worked out by the surface rights owner and the oil company. The settlement arrived at reflects consideration of such factors as inconvenience to the surface owner and the value and size of the acreage used by the oil company. In a few isolated cases the surface owner and oil company need help from an arbiter in reaching a settlement. A government board fills this role.

Finally, the approval of a conservation authority is obtained in the form of a drilling licence. At one time there were no regulatory bodies to govern drilling and producing operations; therefore unintentional, but nevertheless extensive wastes marred the early history of the oil industry in North America. No regard was given to the rate at which oil was withdrawn from the reservoir, nor to the number of wells drilled in the field.

Coincident with the growth of the industry, there came the accumulation of knowledge respecting reservoir characteristics and economical production. Eventually it was recognized that the life and productivity of an oil or gas reservoir would be substantially increased if methods were employed to bring about the orderly development and depletion of the field.

Because Alberta's development has come comparatively late, the industry here has been able to avoid many of the wasteful practices that occurred elsewhere. New methods to increase production efficiency and avoid waste, which had been developed elsewhere, were adapted to Alberta conditions.

In Alberta most producers recognized the need for conservation measures, and in 1938 the Alberta legislature passed the first effective conservation law in the western provinces. Our province's oil and gas conservation measures, carried out by the Conservation Board, on the whole reflect sound engineering practices which have been developed by the industry. An important function of the Board is the establishment of maximum rates at which oil or gas may be withdrawn from a well, and well spacing patterns (location and number of wells drilled in a producing field). These measures ensure orderly development and production of the reservoir and thereby provide for maximum ultimate recovery of the oil or gas being produced.

CHAPTER IV

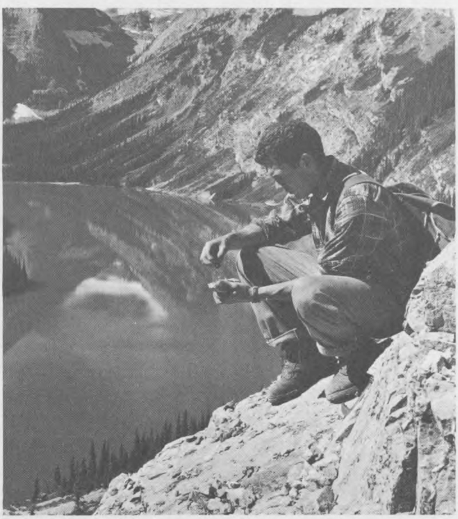
THE WHERE AND HOW OF DRILLING

Drill sites in Alberta are selected with the help of modern geological and geophysical methods, unknown in the days when visible seepages were the main clues.

The geologist has an astonishing guide book, for he "reads" rock layers of the earth from time past, and the tiny sea creatures, preserved as fossils, are his illustrations. Geologists search for clues which may locate places where conditions are favourable for the accumulation of oil and gas.

In a totally unexplored region, the geologist confines his search for information to the area in which oil-bearing formations are most likely to be found. In western Canada this is the sedimentary basin rather than the Canadian shield because oil or gas are found only in sedimentary rock, except in rare instances.

Wherever nature or man has made possible visual examination of rocks, the field geologist searches for clues. Outcrops of rock, river valleys and gorges, mine shafts, irrigation ditches and water wells are all likely sources of information.

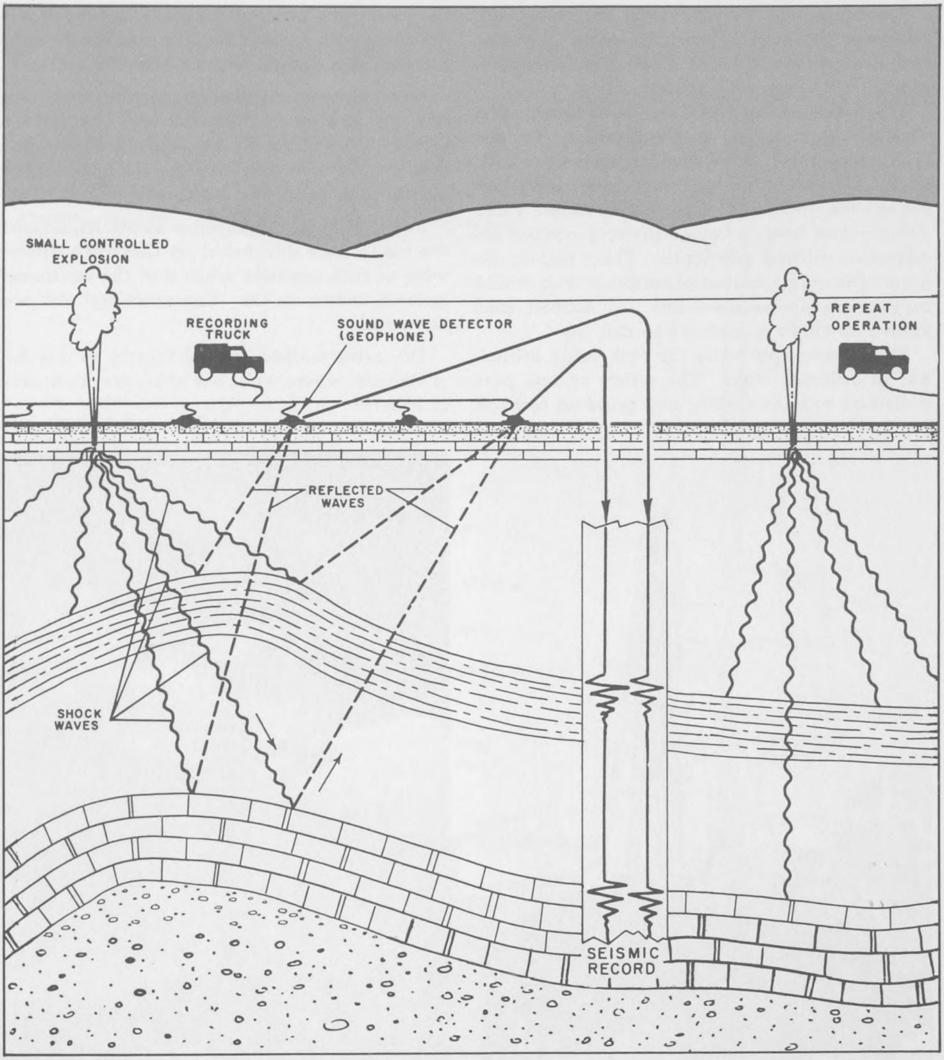


Outcrops of rock in Alberta's Rocky Mountains permit the geologist to visually examine rock strata which in the prairies are buried thousands of feet below the surface.

If an oil company begins exploratory operations in a region where oil industry activity has already taken place however, the situation is made somewhat easier in that geological information is more readily accessible. In addition to information obtained by surface examination, information may be obtained from such sources as government reports, published geological papers and from previous industry drilling. Wellsite geology also plays an important role. In addition to identifying and examining underground strata through which a new well is drilling, the geologist uses the information obtained to broaden his knowledge of the general area.

Thickness of the surface soil in Alberta often handicaps this geological sleuthing by covering up the rocks needed for investigations. This has resulted in a combining of geological and geophysical methods to wrest secrets of rock formations from the earth.

Although there are several tools employed to obtain information respecting underground strata, possibly the most important instrument is the seismograph. Geophysicists measure the depth and relief of subsurface horizons by recording delicate sound waves. They create these sound waves by setting off small charges of dynamite in holes drilled for that purpose. The resultant shock waves travel downward, strike underlying layers of rock and are reflected back to the surface where they are recorded by a seismograph. This instrument has long been used to measure ordinary earthquakes and the version used in the search for oil has been developed specifically for this purpose by industry research laboratories. (It is of interest that the actual recordings are now made on magnetic tape.) The time it takes for the waves to make the trip to the reflecting formation and back are measured in thousandths of a second, and relief maps are made based on these measurements.



Sound waves from small controlled explosions near the surface travel downward, strike underlying layers of rock and are reflected back to the surface where they are recorded by the seismograph. From the time required for the sound waves to travel down to the reflecting rock bed and back to the surface, the depth of the reflecting bed can be determined. These depth measurements taken over several miles, enable geophysicists to draw a relief map of the subsurface rock layers and locate traps which could contain oil or gas. In the above drawing, the travel paths of the sound waves to and from the reflecting rock beds are shown. In the centre, the type of recording obtained is illustrated. In actual practice usually 24 sound wave detectors (geophones) are used to cover up to a mile on the surface.

Geological and geophysical methods help minimize the risk of drilling costly dryholes, but even so the element of chance makes exploration a constant gamble.

When the drilling site has been selected, a drilling rig is moved to the location. At one time cable tools were used exclusively in Alberta. However, the rotary rig gradually displaced the cable tool rig, and in recent years Alberta has been a major proving ground for advanced drilling techniques. These techniques permit faster and deeper penetration than would be possible by the old cable tool method, also known as churn or percussion drilling.

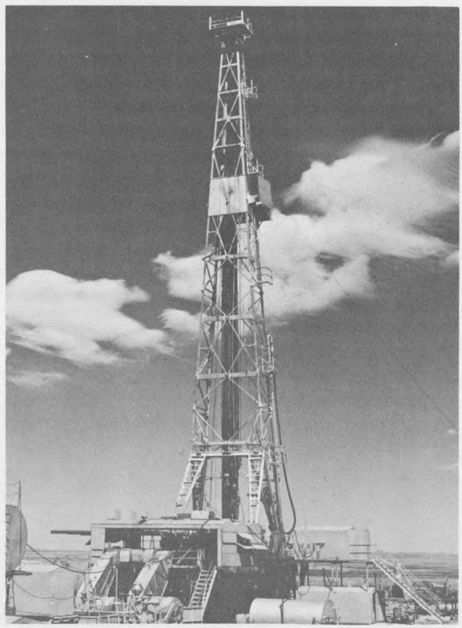
Both systems pulverize the rock being drilled, but in different ways. The rotary system puts a drill bit to work cutting and grinding through the formation, whereas the cable tool rig repeatedly lifts and drops a heavy cutting tool, which punches and pounds out the hole.

Both systems require a derrick (the most familiar symbol of the petroleum industry) to support the drilling equipment; likewise in both cases, a power system provides the force for boring through earth and rock.

Before 1900 all wells were churn drilled, and the cable tools developed by Canada's drillers were of such superior make that the equipment became known as the "Canadian rig" all over the world.

The cable method is used largely to this day in Ontario, where wells are shallower than most in Alberta.

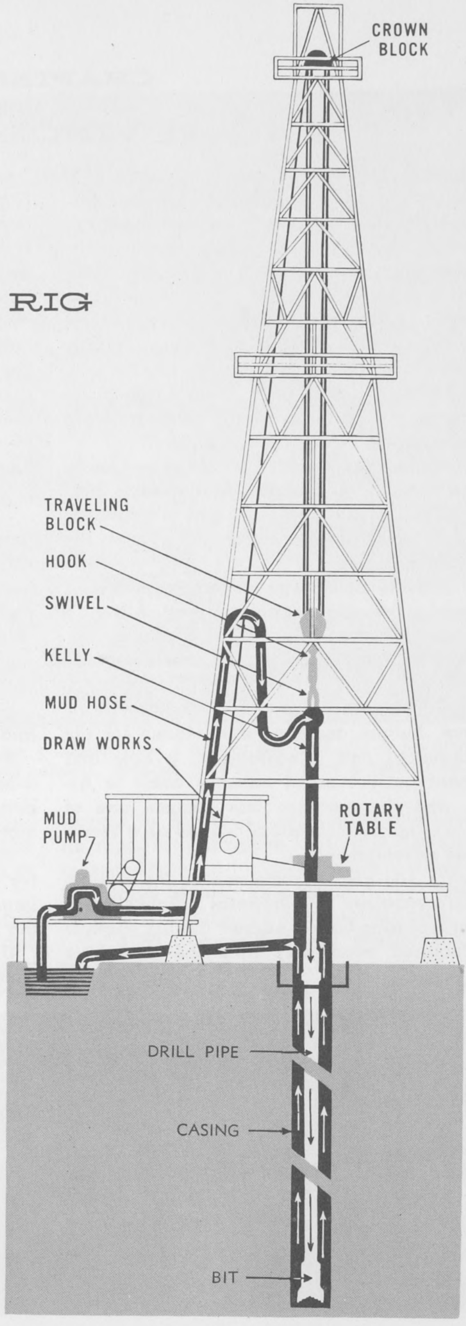
The cable tool rig is still used today in Western Ontario and in other shallow drilling areas in the world where certain rock conditions create special problems for rotary drilling. The cable tool rig drills the well bore by repeatedly dropping a steel tool bit suspended from a cable which is lowered and raised by the rig equipment.



The modern rotary rig, such as shown here drilling in southern Alberta, is capable of drilling to depths up to three miles. Rotary rigs in use in other parts of the world today can drill to depths of approximately five miles.

ROTARY DRILLING RIG

In rotary drilling a power driven rotary table on the derrick floor turns the "kelly," to which the drill pipe is attached. Thus the bit is turned by the rotary motion of the drill pipe. As the bit bores deeper, additional lengths of drill pipe are attached below the kelly. Power to raise and lower the string of drill pipe is supplied through the draw works. Rock cuttings from the bottom of the hole are carried to the surface by specially prepared mud which is pumped down the inside of the drill pipe, through the bit and back to the surface. The mud also cools the bit, seals the the wall of the hole as it returns to the surface outside the drill pipe and helps prevent a well from blowing out of control if unexpected high pressure oil or gas is encountered.



CHAPTER V

A PROVINCE GROWS

Although the full impact of Alberta's 1947 transformation into recognized oil country cannot be measured in money alone, the industry's economic contributions have been monumental.

Provincially, the Alberta Government's largest single source of revenue is from oil and gas. The industry has provided huge sums for education, public health services, highways, welfare services and community improvements in general. As the industry grew it encouraged Albertans to industrialize — get away from the single economy based on agriculture.

The oil and gas industry attracted people as well as capital to Alberta. At the same time multi-million dollar pipe mills and other industries developed to help equip and service the oil industry.

The industry built large modern oil refineries and gas processing plants to meet Alberta's growing needs and meet export demands.

This refining and processing of petroleum and natural gas has had a significant side effect, by providing such important raw materials as propane, butane, methane and ethane for the petrochemical age. Accordingly, a new and important petrochemical industry came to Alberta, and the province has become one of Canada's top petrochemical centres as a result of these developments.

Alberta has also become one of the world's leading producers of elemental sulphur, with several thousand tons of highest quality sulphur manufactured every day from the province's natural gas.

Establishment of one industry frequently leads to more industry. Many have settled in Alberta because they can make use of local sulphur or certain petrochemical products in their own manufacturing operations. These, in turn, perpetuate the chain reaction by attracting other industries.

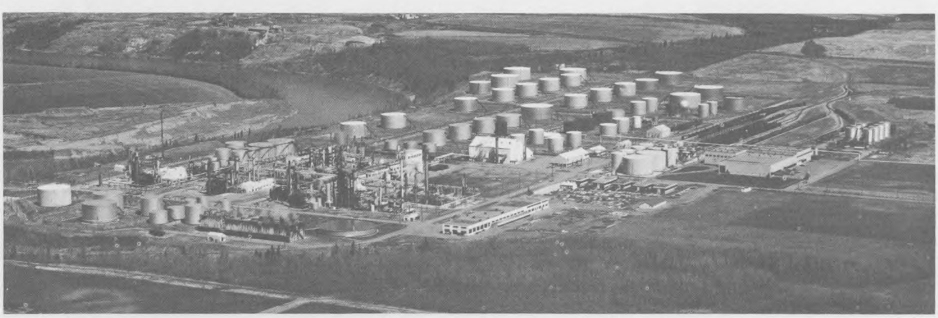
The petroleum industry is a large employer. The skills of its employees are among the most important assets of oil and gas companies. The industry demands many skills and professions because of its varied operations — exploration, land acquisition, production, refining, processing, research, transportation and marketing.

Working in the industry are management officials, engineers — especially petroleum, chemical and mechanical engineers — geologists, geophysicists and other scientists, assisting technicians and field personnel, landmen, purchasing agents, computer programmers, professionals in such fields as law, labour relations and economics, supervisors, clerks, switchboard operators, secretaries, stenographers, typists and others.

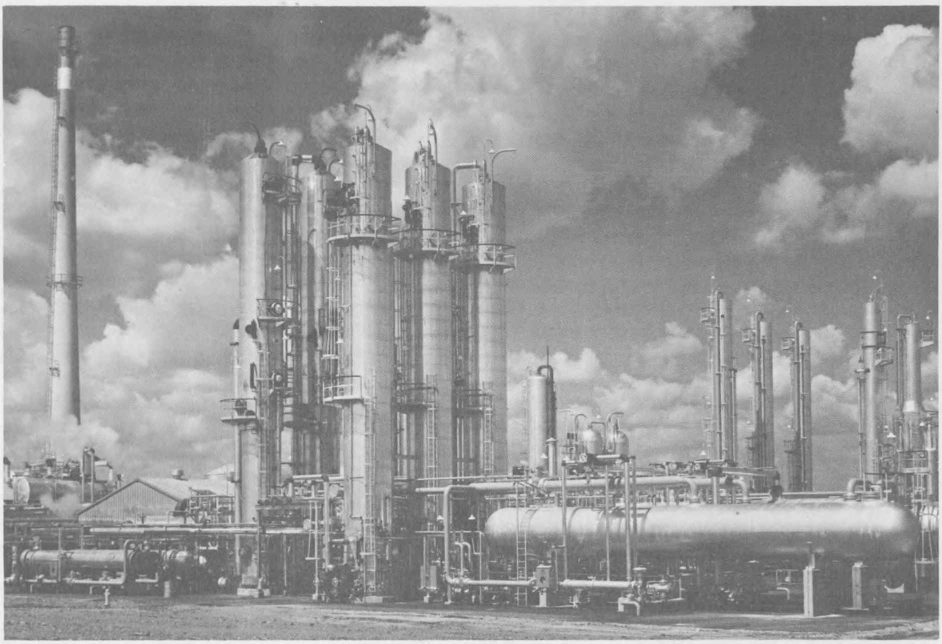
The oil and gas industry, in addition to being a large employer, also is one of Canada's important consumers of Canadian goods and services.

The growth of a Canadian oil and gas industry also meant that Canada could assume an important share of the responsibility of supplying North America's energy requirements.

Until 1947 Canada had to rely on foreign countries for 90 per cent of its petroleum needs.



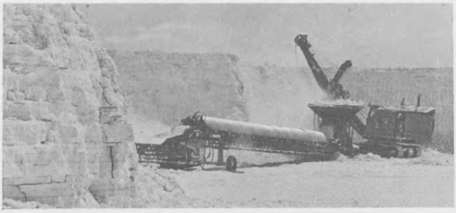
An aerial view of a modern refinery in Edmonton's "chemical valley".



This gas plant in central Alberta processes raw gas produced from a nearby gas field and is the source of large quantities of propane, butane, condensate and sulphur. Residue gas from the plant is used as industrial and domestic fuel.

Foreign crude supplied every refinery in Canada except those in Alberta. Even in 1950 Canada still imported more than 60 per cent of all its fuel needs.

As Canada's largest oil and gas producing province, Alberta provides not only most of Canada's domestic requirements, but also most of its export volumes. Discovery of reserves surplus to Alberta's needs made this possible. As supplies outstripped Canadian domestic requirements, export markets were developed in the United States. This meant further improvement in Canada's export-import balance.



Large quantities of elemental sulphur are manufactured daily at many of Alberta's gas processing plants. Here it is loaded to a crusher then moved by a conveyor belt to railway cars for shipment.

By 1980 Canada's energy requirements, already the second largest in the world, should be almost double the level of the early 1960's.

It is forecast that use of oil and gas even with the energy rate nearly doubled, will account for more than 70 per cent of the total.

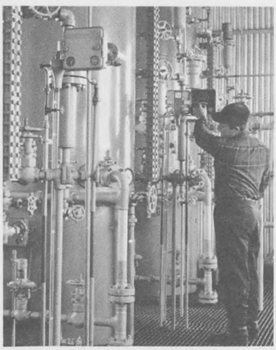
Already there are several hundred oil and gas fields or gas "areas" to draw from in Alberta, but more reserves must become available to safeguard the Alberta economy and provide continuity of supply to future Canadian and export markets.

The oil explorers, whose work of yesterday provided today's reserves, now concentrate on the task of finding further adequate supplies for tomorrow.

THE PETROLEUM INDUSTRY DEMANDS MANY SKILLS AND PROFESSIONS. TO NAME A FEW...

GEOLOGY

CLERICAL

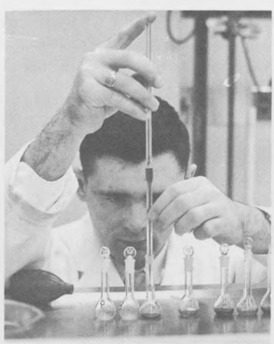


GAS PLANT OPERATIONS

COMMERCE

REFINERY OPERATIONS

SECRETARIAL



CHEMISTRY

SALES

CHAPTER VI

NATURAL GAS - A Thousand Uses

Now accepted as the fuel of a thousand uses, for many years natural gas was unwanted. Even in relatively recent times it was considered just a by-product of exploration for oil. Usually gas wells remained "shut-in" until adequate markets developed. Now gas utilization is recognized as a big, separate industry in its own right.

Natural gas performs a great many domestic, industrial and commercial services. Its household uses take in such jobs as cooking, refrigeration, home heating, water heating, clothes drying and incineration. Industrially, natural gas is used as fuel for machines that make a host of products, ranging from candies to television tubes.

The gas that powers the machines in factories also can be used for heating, air-conditioning and incineration — similar uses to those in the home. Commercially, it finds application just about everywhere. A few examples are laundries and dry cleaners, printing plants and restaurant kitchens. It is used even for generation of electricity.

This domestic, commercial and industrial fuel is called "dry" gas and consists almost entirely of methane.

Natural gas is widely used in the modern household, and also performs a great many industrial and commercial services.

However, much of Alberta's natural gas comes originally from "wet" fields, many of which are located in the foothills areas. The "wet" gas from such fields contains varying quantities of "natural gas liquids" such as ethane, propane and butanes, pentanes plus, and condensate or natural gasoline.

Propane and butanes are known as liquefied petroleum gases or L.P.G. Condensate can be described best as a very light crude oil. Pentanes plus and natural gasoline are similar to condensate, but are more volatile. Pure ethane is normally a gas with physical and chemical properties between methane and propane.

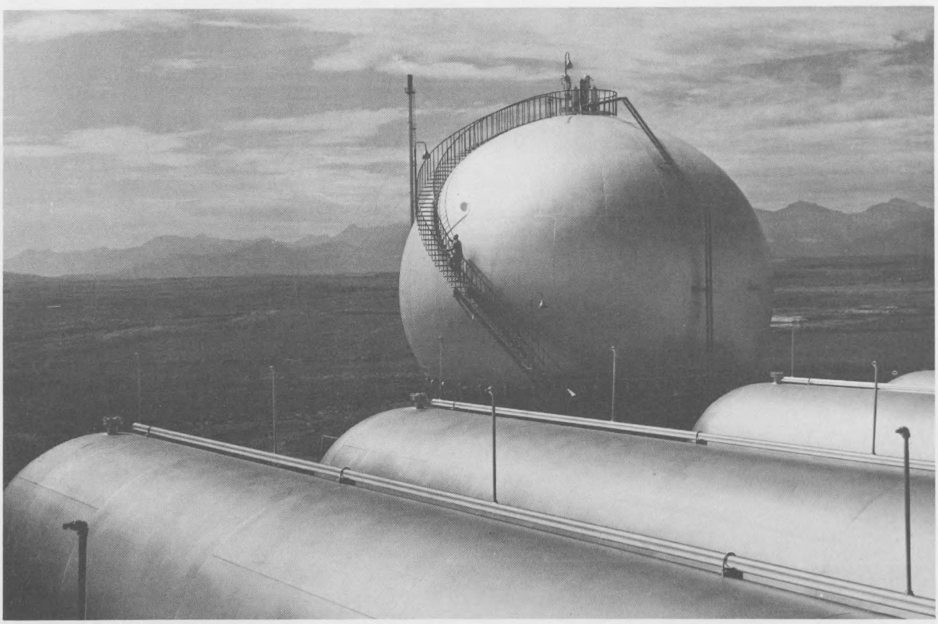
These and hydrogen sulphide are removed before the dry gas goes to market. Gas processing and sulphur plants built for this purpose in Alberta have cost several hundred million dollars.

Natural gas liquids and sulphur are versatile workers. Sulphur, either in the form of sulphuric acid or as a primary raw material, is used in almost every major manufacturing process. It is used, for example, in the manufacture of such diverse products as explosives, fertilizers, paper, paints, medicines and even sugar. Alberta's bright yellow sulphur has become established in world markets.

Condensate and natural gasoline are in demand by refiners in both Canada and the United States. They are used in the production of motor gasoline and diesel fuel.

Propane, butanes and ethane serve as raw materials for petrochemical industries. Propane and butane, especially the former, also are widely used on the farm for heating. In addition, they find use as engine fuels, industrial or plant fuel, and in pressure maintenance programs to increase oil recovery.

Use of Alberta natural gas reduces the nation's imports bill by tens of millions of dollars annually. Included are savings on natural gas, once imported, and huge reductions in imports of coal and sulphur.



At many gas plants in Alberta these tanks are a common sight. The cigar-shaped cylinders in the foreground are for storing propane and butane. The large spherical tank is for condensate storage.

CHAPTER VII

ON THE MOVE

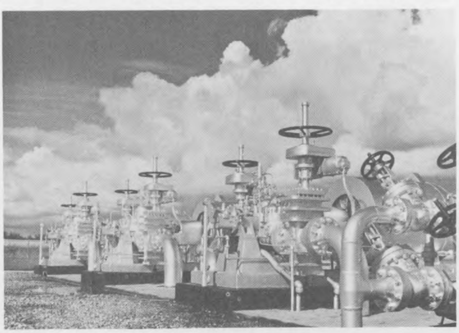
Transportation of crude oil, petroleum products and natural gas is one of the most important phases of the petroleum industry. The cost of transporting these commodities to market also is one of the major items of cost for oil and gas industries.

Natural gas is transported by pipe lines from the producing fields to the processing plants, then via large diameter trunk systems to cities and industrial markets. Distribution companies receive the gas from the large gas pipe lines and distribute it to industry as fuel and to homes where it is consumed as domestic fuel for heating and cooking purposes. Many thousands of miles of pipe lines have been built to gather the gas and transport it from plants in Alberta to markets in Vancouver, California and in eastern Canada, as far away as Montreal.

On the other hand several methods of transportation are used for crude oil and petroleum products — truck, rail, pipe line and water — and most of these methods are used in Alberta. Pipe lines are the most economic method of moving large quantities of oil over long distances throughout Alberta and to other markets in eastern and western Canada. But further large quantities are on the move constantly in railway tank cars and in tank trucks. Unknown in Alberta's petroleum transportation system is another highly economic method of moving crude oil — movement by large ocean tanker. These are used in international movement of petroleum, and smaller versions of tankers ply coastal waters and eastern Canada's Great Lakes.

RAILWAY TANK CAR

OIL TANKER



PIPELINE

TANK TRUCK

In 1912 this load of pipe, delivered by railway to Claresholm, was taken by a 12 wagon tractor train to a construction location on the Bow Island to Calgary pipe line.

In Alberta most of the crude oil produced in established fields is transported to the refineries and collecting points by crude oil pipe lines. In remote areas the crude oil is transported from the wells to either pipe line terminals or refineries by truck. Also, where it is economically feasible, some crude oil may be transported by railway tank car to the nearest marketing terminal, which may be another refinery or a pipe line.

In the early days of the oil business in North America, wooden barrels were used to transport crude and products. The barrels were hauled in horse-drawn wagons or barged on scows. Where streams were handy the barrels sometimes were floated downstream from oil fields to reach vessels in deep water. Subsequently the railway tank car was invented which received crude from the tank-wagons and transported it to refineries.

But today in Alberta,pipe lines handle by far the largest part of transportation in the petroleum industry. The first major pipe line in the province was built to move natural gas. This was the 170-mile, 16-inch diameter line from the Bow Island gas field to Calgary, via Lethbridge, and its construction in 1912 still is regarded as a pipe line milestone in western Canada. At the time, it was the third longest pipe line in North America, and it established a record for size because the longer lines were made of smaller pipe.

The line was built by the gas company which still serves Calgary and southern Alberta. Today the firm, and its associated company headquartered in Edmonton, operate more than 4,500 miles of gas transmission lines. Another company operates a pipe line grid more than 1,500 miles long to gather gas from many fields throughout the province, and supplies it to local distributors. Thus communities from one end of Alberta to the other receive natural gas service.

Gas from Alberta moves to market in eastern Canada through a pipe line which marked another record for the gas industry in the province. Originating in Alberta, the line ends at Montreal, and is the longest natural gas pipe line in the world. In order to penetrate markets so many miles from the source of supply, the gas industry spent many millions of dollars in exploration. This was necessary in order to establish adequate reserves to ensure the new markets with continuous supply over many years.

Serving markets so far afield (Quebec, West Coast, California) creates the situation that will keep Albertans in a favourable position in the matter of gas prices. Users of Alberta gas many miles from the fields must pay rates which include the cost of transporting the gas through the various pipe line systems. Local consumers, on the other hand, are not burdened with these long distance transportation costs. However, without the availability of these large export markets, development of many of Alberta's major gas fields would not have been feasible. The comparatively small local demand would not have justified the great expense in developing the field, building plants to process the raw gas, and laying pipe lines.

Although large volumes of gas reserves have

Pipe line construction in the 1920's was largely a manual job. Here pipe is being coupled together during the building of the gas line from the Turner Valley field to the City of Calgary.

been committed to export, the needs of the province have been given first consideration. It is provincial government policy that Alberta's needs in the foreseeable future be met before gas in excess of these requirements is dedicated to export markets.

When oil pipe lines are added to gas pipe lines, the total pipe line mileage is impressive. The first major crude oil pipe line followed soon after the 1947 Leduc discovery, and expansion of pipe line facilities in Canada has paralleled the growth of exploration and production. The first big step in getting Alberta oil to market was the construction of a line from Edmonton to Superior, Wisconsin, at the head of the Great Lakes, in 1950. The line later was extended to the Toronto area.

The second major step was the construction of Trans Mountain Oil Pipe Line from Edmonton, Alberta, to a point near Vancouver, British Columbia. This line was also extended across the border into the United States to supply Canadian crude to U.S. refineries in Washington.

Alberta oil moves in continuous flow through these major pipe lines serving the Canadian West Coast, the U.S. Pacific Northwest and to markets as far east as Ontario.

Many miles of pipe lines are also constructed for the purpose of gathering crude produced from the many thousands of oil wells scattered throughout the producing fields. Small diameter pipe lines (called flow lines) collect oil from the producing wells and deliver it to a central storage point — a "tank battery." Pipe line gathering systems then transport the crude oil to main transmission systems for further transportation to refining centres.

The location of many refineries permit them to purchase from many sources throughout the world, wherever oil may be bought most economically, and it may be received by pipe lines, trucks, tank cars or ocean tankers. There may be other factors, of course, that affect crude prices, such as very low finding costs and low producing costs, as is the case with some of the large foreign oil sources. However, where this situation does not apply, the transportation system used in delivering the oil to the refinery may determine whether or not the crude oil is competitive in price with crude from other sources. Insofar as overland transportation of crude oil is concerned, pipe lines by far are the most competitive and economic in transportation cost. As an example, one gallon of oil produced in Leduc, Alberta, may be delivered to a refinery in Toronto, Ontario, by pipe line for about the same cost as sending a postcard by mail between these two points.

The development of this large diameter pipe has made it economically possible to move oil and gas over great distances at low cost. Today the natural resources of Alberta sell in distant markets which could not have been reached otherwise.

The cost of transportation may also apply to determine the competitive price of natural gas. In its export markets in the United States, Alberta gas has to compete with natural gas produced from other domestic sources, and in eastern Canada it has to compete with other types of fuels. Therefore, the cost of transportation is quite important in acquiring and securing markets for Alberta's oil and natural gas.

A major economic advantage of pipe line movement of crude oil and natural gas is its non-stop operation. A main transmission pipe line for oil or gas operates continually and with very small cost of manpower. Pumping and compression stations located at intervals along the pipe line keep the pipe lines flowing, silently underground Until a new field has been developed to the point that would justify the installation of a pipe line, the first crude oil production is usually handled by tank trucks or railway tank cars, or both. As soon as sufficient production has been obtained, the transportation costs are reduced by the installation of the pipe line.

Refined petroleum products are also transported by the various methods used for crude oil. Tank cars and tank trucks (and in some areas pipe lines) deliver products, such as gasoline and fuel oil, to "bulk stations" that are strategically located throughout the marketing area of a province. Here products are stored for subsequent delivery to service stations, industrial plants, or homes. Deliveries of products and lubricants are made similarly to farms and industrial plants.

CHAPTER VIII

REFINING - The Building Block Business

Whereas rocks serve as reservoirs for petroleum and natural gas, the latter, in turn, are virtually inexhaustible "reservoirs" of substances for production of a large range of products.

It is the business of Alberta's oil refineries, processing plants and petrochemical installations to tap this great products potential in their individual ways.

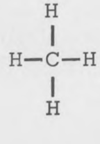
Motor gasoline and other fuels emerge, for example, from one set of operations while a variety of other operations constantly expand the wonder world of synthetic or petrochemical products — clothes you don't press — containers you do press . . .

The range of products extends from necessities to luxuries, and in keeping with Canada's high standard of living, today's luxuries probably will be tomorrow's "necessities."

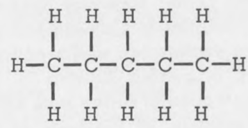
All chemical compounds consist of molecules built up from atoms of elements. Natural gas and crude oil molecules, for example, are made up basically of atoms of carbon and hydrogen. (All living things contain carbon. The little sea creatures that lived millions of years ago were no exception. Thus, petroleum and natural gas contain carbon because they were made of the remains of those tiny sea things.)

Since petroleum and natural gas are compounds of carbon and hydrogen, the substances found in crude oil and natural gas are called hydrocarbons. It is the task of refiners and processors to separate petroleum and natural gas into these different substances which range from light gases, such as methane, through liquids, such as pentane, to heavy solids containing very many carbon atoms.

In a molecule of methane, the lightest gas component, one carbon atom is joined with four hydrogen atoms. This is the simplest chemical compound.



Pentane — a liquid — has five carbon atoms and has a formula as follows:



Solid hydrocarbons have a relatively large number of carbon atoms, and are much more difficult to illustrate.

Keys to industry's separation processes lie in the fact that different substances boil at different temperatures. This permits ready separation by distillation. That accomplished, the various isolated materials then are manufactured into the kinds of products wanted. This involves a number of operations, and these are described generally as conversion, treating and blending.

Here are some of the products separated from petroleum: L.P.G. (liquefied petroleum gases), petrochemicals, gasoline, kerosene, heating oil, jet fuels, diesel fuel, heating fuel, light industrial fuel oil, heavy fuel oil, greases, lubricating oils, waxes and asphalt. For about half a century gasolines have been the most important products of refineries.

The variety of compounds produced for chemical and petrochemical markets reflects the skill of refiners in re-ordering the structures of hydrocarbons. Some are useful products in their own right. Others function as "building blocks" in the creation of fascinating synthetic products. Included are ethylene, propylene, butylene and butadiene.

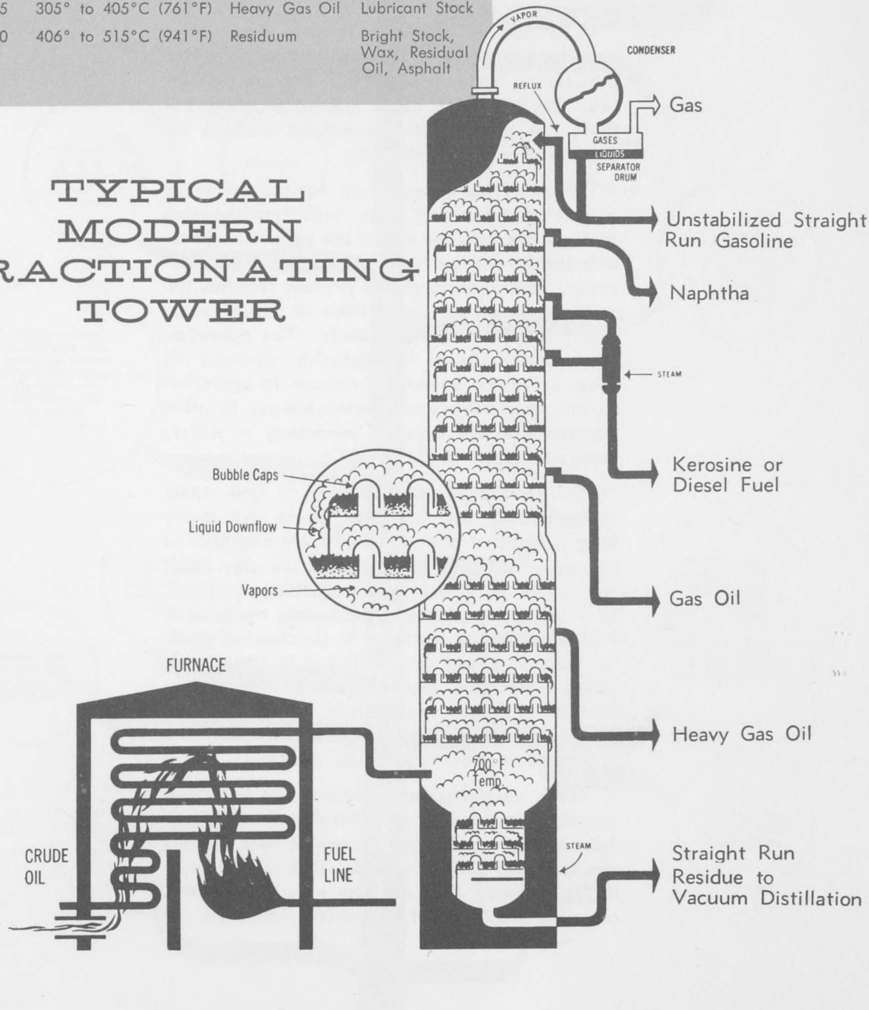
The number of possible chemical compounds from Alberta's oil and gas is almost unlimited. In turn, the number of products that can result from this oil and gas are seemingly endless.

Already at least 500,000 chemical compounds can be made from petroleum hydrocarbons. This number may be more than doubled within a few years. The long list of synthetic products will lengthen proportionately.

BOILING RANGES OF PETROLEUM FRACTIONS

Range of Carbon Atoms	Boiling Range	Name of Fraction	Principal Uses
1 to 5	Below 40°C (104°F)	Gas	Fuel
6 to 10	40° to 180°C (356°F)	Gasoline	Fuel
11 to 12	180° to 230°C (446°F)	Kerosine	Fuel, Cracking Stock
13 to 17	230° to 305°C (581°F)	Light Gas Oil	Cracking Stock, Diesel Fuel
18 to 25	305° to 405°C (761°F)	Heavy Gas Oil	Lubricant Stock
26 to 60	406° to 515°C (941°F)	Residuum	Bright Stock, Wax, Residual Oil, Asphalt

TYPICAL MODERN FRACTIONATING TOWER



CHAPTER IX

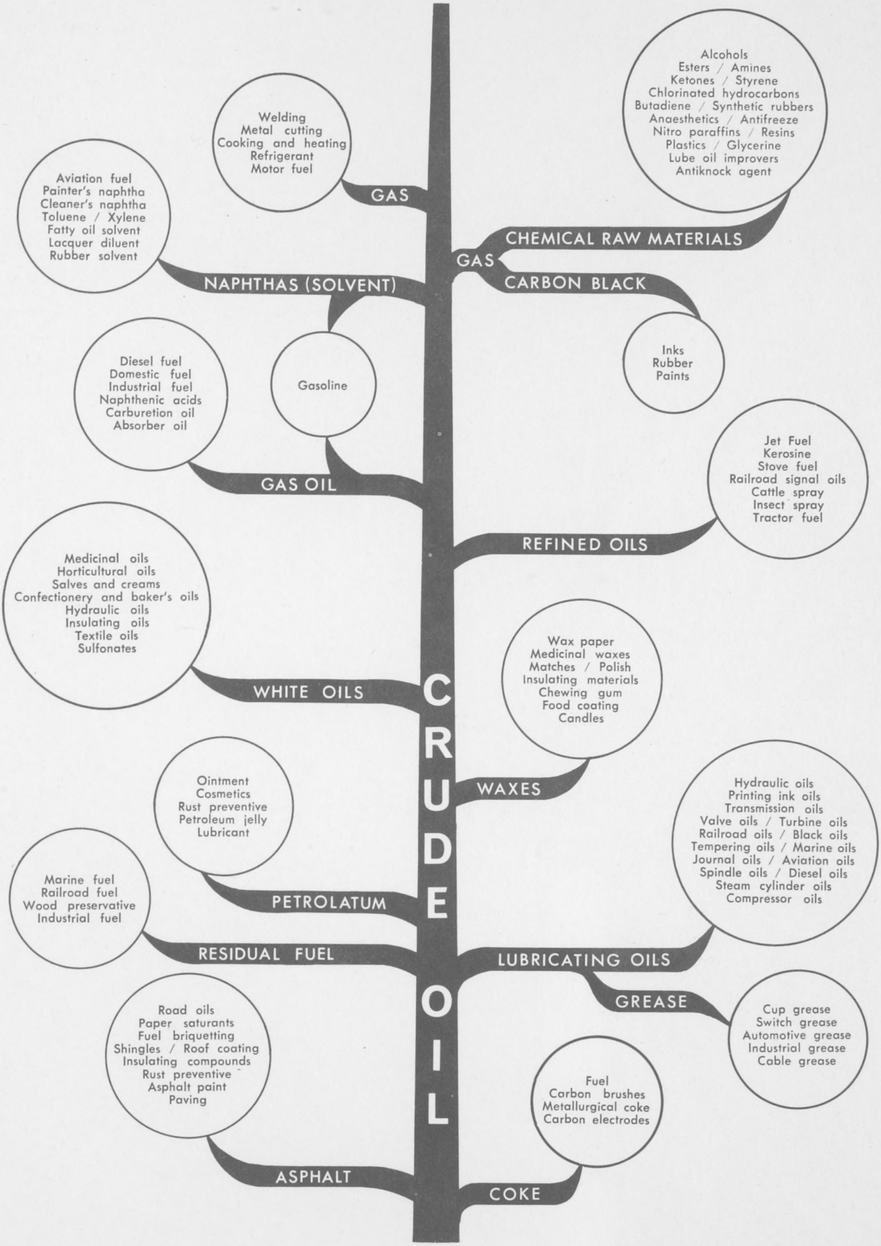
CONTINUED . . .

The story of petroleum is more than a description of its main divisions of exploration, production, transportation, refining and marketing. Each division has a special function, but these are not isolated operations working independently of one another.

There is an orderly and logical sequence of events beginning with initial exploration and ending with the use of the petroleum products by the consumers; and the smooth uninterrupted continuation of this process requires the integration of these operations at many supervisory and management levels. The operation of each division of the industry concerns all other divisions, because a change in operation in one area may necessitate changes in other segments of the industry operating in widely separated parts of the world.

Oil companies differ greatly in size, areas of operation, and interests. There are many fully integrated companies actively engaged in all aspects of petroleum. There are also small companies with perhaps a fractional interest in a few oil wells; and marketing companies, whose activity is confined to purchasing product from a refiner and selling it to consumers. These companies, regardless of size, are members of a highly competitive industry. Each has its place in bringing a never-ending flow of petroleum products to the consumer.

Much petroleum and natural gas has been searched for, found and developed so far in Alberta, but much more petroleum and natural gas is yet to be discovered. It is a story still in the making. It is far from over . . . so now, as in the past, it must be marked continued . . .



CRUDE OIL
GAS
Welding
Metal cutting
Cooking and heating
Refrigerant
Motor fuel
CHEMICAL RAW MATERIALS
GAS
Alcohols
Esters / Amines
Ketones / Styrene
Chlorinated hydrocarbons
Butadiene / Synthetic rubbers
Anaesthetics / Antifreeze
Nitro paraffins / Resins
Plastics / Glycerine
Lube oil improvers
Antiknock agent
CARBON BLACK
Inks
Rubber
Paints
NAPHTHAS (SOLVENT)
Aviation fuel
Painter's naphtha
Cleaner's naphtha
Toluene / Xylene
Fatty oil solvent
Lacquer diluent
Rubber solvent
Gasoline
GAS OIL
Diesel fuel
Domestic fuel
Industrial fuel
Naphthenic acids
Carburetion oil
Absorber oil
REFINED OILS
Jet Fuel
Kerosine
Stove fuel
Railroad signal oils
Cattle spray
Insect spray
Tractor fuel
WHITE OILS
Medicinal oils
Horticultural oils
Salves and creams
Confectionery and baker's oils
Hydraulic oils
Insulating oils
Textile oils
Sulfonates
WAXES
Wax paper
Medicinal waxes
Matches / Polish
Insulating materials
Chewing gum
Food coating
Candles
PETROLATUM
Ointment
Cosmetics
Rust preventive
Petroleum jelly
Lubricant
LUBRICATING OILS
Hydraulic oils
Printing ink oils
Transmission oils
Valve oils / Turbine oils
Railroad oils / Black oils
Tempering oils / Marine oils
Journal oils / Aviation oils
Spindle oils / Diesel oils
Steam cylinder oils
Compressor oils
RESIDUAL FUEL
Marine fuel
Railroad fuel
Wood preservative
Industrial fuel
GREASE
Cup grease
Switch grease
Automotive grease
Industrial grease
Cable grease
ASPHALT
Road oils
Paper saturants
Fuel briquetting
Shingles / Roof coating
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Asphalt paint
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Fuel
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